Aliasuddin, Aliasuddin; Effendi, Rustam; Samsudin, Hazman et al.

Article

The dynamic role of fiscal and monetary policies on energy efficiency in Indonesia

International Journal of Energy Economics and Policy

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2024, 14(6), 420-425.

The Dynamic Role of Fiscal and Monetary Policies on Energy Efficiency in Indonesia

Aliasuddin Aliasuddin[1]*, Rustam Effendi[1], Hazman Samsudin[2], Nanda Rahmi[1,2], Kamal Fachrurrozi[1]

[1]Faculty of Economics and Business, Universitas Syiah Kuala, Indonesia, [2]Faculty of Business, Economics, and Social Development, Universiti Malaysia Terengganu, Malaysia. *Email: aliasuddin@usk.ac.id

Received: 26 June 2024 **Accepted:** 04 October 2024 **DOI:** https://doi.org/10.32479/ijeep.17203

ABSTRACT

This study analyzes the dynamic influence of monetary and fiscal policies on energy efficiency in Indonesia. Quarterly data from the first quarter of 2000 to the fourth quarter of 2023 with a sample size of 96 quarters and the ARDL model are used in this study. The results of the short-term dynamic study show that monetary and fiscal policies significantly affect energy efficiency in Indonesia. However, dynamic economic growth does not affect energy efficiency. Furthermore, there is no difference in the influence of dynamic monetary and fiscal policies on energy efficiency in Indonesia. The monetary authority and the government of Indonesia must use monetary and fiscal policies to improve efficiency in Indonesia. Energy efficiency is very important not only in the use of natural resources but also in environmental damage due to inefficient energy use.

Keywords: Energy Efficiency, Fiscal Policy, Monetary Policy, Indonesia
JEL Classifications: E52, E62, Q43, Q48

1. INTRODUCTION

Indonesia, with the fourth-largest population in the world, has huge economic consequences for meeting the needs of the entire community. Increased economic activity will result in increased energy used to produce goods and services needed by the community. Indonesia is interested in reducing fossil fuels because fossil fuels produce very large emissions. Increasing the proportion of new renewable energy is very important for Indonesia to achieve emission reductions.

Indonesia has been trying to achieve net zero emissions (NZE) by 2060 by meeting energy needs from new and renewable energy sources (IESR, 2023). However, IESR (2023) reported that the current condition is still far from efforts to reduce emissions from the energy sector in Indonesia. Furthermore, IESR (2023) stated that the contribution of renewable energy is still <10 percent of the total energy in Indonesia. The contribution of fossil energy is still very dominant, with a contribution of 90% in 2022 (IESR, 2023). This usage condition is still very worrying because the contribution of fossil energy is still very dominant. The main sector that dominates this emission comes from the electricity sector, with an estimated contribution of 414 MtO2 in 2030 (IESR, 2023). Based on these conditions, two sides must be done to reduce emissions. First, increasing the contribution of renewable energy to the total energy used in Indonesia will cause the contribution of fossil energy to experience a significant decrease. Second, the efficiency of energy use in the Indonesian economy because through the efficiency of energy use, emissions can be reduced due to the optimization of energy use in the production process in Indonesia. This efficiency can be achieved through fiscal or interest rate incentives that will encourage business actors to use energy efficiently in the production process.

The transportation and industry sectors are the largest producers of greenhouse gas (GHG) emissions, with 86 percent in 2030 and an increase of 98% in 2060 (IESR, 2023). These two sectors are very large contributors because the production process requires energy in industrial products' production and transportation processes. Policies encouraging the industrial sector to use renewable energy are one alternative to GHG emissions.

Fiscal and monetary policies are expected to be important instruments in improving energy efficiency in Indonesia. Fiscal and interest rate incentives are some solutions to improve energy efficiency. Energy efficiency is very important because the development of the Indonesian economy is getting bigger, so the need for energy is also very large.

The role of energy efficiency is very important in reducing emissions and, at the same time, increasing competitiveness because efficient use of input will result in lower output prices. Thus, competitiveness increases due to increased energy efficiency. Figure 1 shows that energy efficiency decreased from 2001 to 2003 and then increased in 2004. There was a decline in energy efficiency over a very long period from 2005 to 2021. The increase in energy efficiency occurred again after the COVID-19 pandemic and decreased again in 2022.

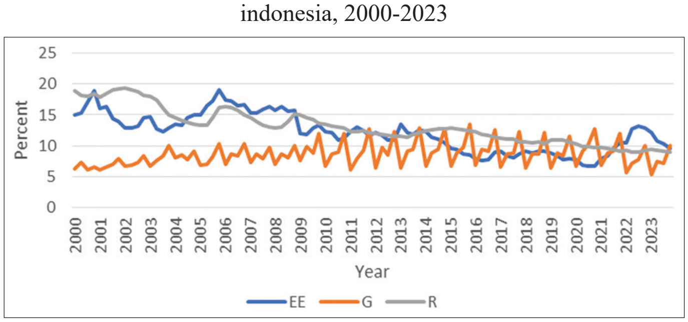
The development of government spending as an instrument of fiscal policy has not changed much from 2010 to 2023. The pattern of monetary policy development is almost the same as the development of energy efficiency. These data show that fiscal and monetary policies do not seem to affect energy efficiency in Indonesia.

Sineviciene et al. (2017) found that the economy greatly influences energy reduction and efficiency in 11 Eastern European countries. Capital formation and the industrial sector's economic contribution are other factors influencing energy efficiency. This proves that greater economic development will result in an economy of scale to achieve energy efficiency.

Meanwhile, Syaifudin et al. (2015), using the Computable General Equilibrium (CGE) model, found that fiscal policy will affect emission reduction through energy efficiency in Indonesia. East Indonesia experienced the greatest efficiency impact of fiscal policy in the Sulawesi region and the lowest in Java-Bali. These two regions have different characteristics; the Sulawesi region has a relatively low economy compared to Java-Bali, the region with the most.

Several other studies analyze sector energy efficiency, such as Kusumadewi and Limmeechokchai (2015), Irsyad and Nepal

Figure 1: Energy efficiency, fiscal policy, and monetary policy in indonesia, 2000-2023



(2016), Rosita et al. (2020), Rahardjo et al. (2021), Adha et al. (2021), Liu et al. (2022), and Wu et al. (2023). These studies are sectoral and partial, while Bai et al. (2024) use an aggregate approach for all resources, including energy. This means that an aggregate energy efficiency analysis has not been carried out in Indonesia, especially how fiscal and monetary policies dynamically influence Indonesia. This study is an excellent policy reference for Indonesia because the economy continues to grow, and energy use is increasing. Increased energy use will affect the increasing GHG. This condition will greatly affect the increasing temperature of the earth.

2. LITERATURE REVIEW

Sineviciene et al. (2017) analyzed the determinants of energy efficiency in 11 Eastern European countries using the stochastic frontier function approach model. Energy efficiency in this study was measured by GDP per 1 kg of oil. This is one of the measures used for energy efficiency. The results of their study prove that GDP per capita is the main factor influencing energy efficiency in Eastern Europe. This condition is very logical concerning the economic scale. The greater the economic activity at a certain stage, the more efficiency will be achieved.

Syaifudin et al. (2015) studied the impact of fiscal transfers on several regions in Indonesia; in the study, Indonesia was divided into Sumatra (R1), Java-Bali (R2), Kalimantan (R3), Sulawesi (R4), and East Indonesian Region (R5). They used the Computable General Equilibrium (CGE) model approach. The study results showed that fiscal transfers are Indonesia's most effective instrument for energy efficiency. Region 5 (R5) is the region that experiences the greatest impact of fiscal transfers on energy efficiency, and the smallest is in Region 2 (R2). Economic activities in R2 are relatively very large and already dense, so it is difficult to increase efficiency compared to R5, which is still experiencing vibrations of increasing economic activities.

Nurcahyanto et al. (2020) used the SWOT–AHP model to analyze energy policies and their impact on energy efficiency in Indonesia. The results of this study prove that policy regulation and financial incentives can increase energy efficiency in Indonesia. They are further evidence that the right policies can achieve energy efficiency in Indonesia. The combination of policies supported by financial incentives will be an even better factor in achieving energy efficiency.

No matter how small, any energy efficiency will be very important to reduce emissions from all sectors. Irsyad and Nepal (2016) used a survey method to analyze the energy efficiency of street lighting because street lighting contributes to unwanted government spending. The study results showed that reducing street lighting consumption can achieve an energy efficiency of 2.1 terra watts per year, equivalent to 2.4 million tons of CO_2 reduction. This energy efficiency not only reduces emissions but can also reduce government spending by USD 46.8 million per year.

Rahardjo et al. (2021) analyzed energy efficiency in government buildings in Bengkulu Province using the energy consumption intensity (ECI) approach for goods that use energy, such as lighting, air conditioners, etc. The study showed a 13% decrease in energy consumption from 40.9 kWh/m^2/year to 35.6 kWh/m^2/year. In Indonesia, which has 38 provinces, a 13% decrease in energy use will significantly reduce emissions.

Energy efficiency is inseparable from the type of energy used. Using fossil energy will cause energy inefficiency, while renewable energy can achieve energy efficiency. A study conducted by Nugroho and Syaifudin (2018) in Indonesia proved this. The results confirmed that using renewable energy can achieve energy efficiency. This study shows the need to increase renewable energy sources to achieve energy efficiency and reduce emissions.

Hasan et al. (2012) stated that Indonesia produces very large GHG because most of Indonesia's energy sources are nonrenewable, such as crude oil, coal, and natural gases. Furthermore, they stated that Indonesia has very large renewable energy reserves such as solar, wind, micro-hydro, and biomass. Switching to renewable energy will help reduce GHGs and increase efficiency in energy use. Increasing the composition of renewable energy is also very important to ensure energy security in Indonesia. Erahman et al. (2016) analyzed energy security in Indonesia using five dimensions: availability, affordability, accessibility, acceptability, and efficiency, and compared them with 71 other countries. The study showed an increase in energy security through three dimensions: availability, affordability, and accessibility. However, there is no efficiency dimension of Indonesia's energy security. This illustrates that the efficiency factor must receive very serious attention so that there is a decrease in GHG in Indonesia and an increase in Indonesia's economic activity.

Energy efficiency can also be obtained from household electricity use, such as a study conducted by Adha et al. (2021) using a two-stage analysis of the residential consumption approach. They found that household electricity efficiency was 87.2% in the short term and 45.5% in the long term. This means that a 1 percent reduction in household energy use will affect energy efficiency by 0.13 and 1.45% in the short and long term, respectively. Based on the results of this study, the government can reduce energy use through fiscal incentives for energy-efficient electricity use.

Kusumadewi and Limmeechokchai (2015) also studied the energy efficiency of the residential sector, comparing the energy efficiency of Indonesia and Thailand's residential sector. They used the demand-side management (DSM) approach as an option for reducing residential sector emissions. The study results found that Indonesia could reduce energy efficiency by 27.6% in 2050, equivalent to a 16% reduction in emissions. Meanwhile, Thailand reduced energy efficiency by 15.5% in 2050, equivalent to a 13.36% reduction in emissions.

Meanwhile, energy efficiency in the industrial sector has been studied by Rosita et al. (2020) using the IPCC guideline found that energy efficiency in the industrial sector can reduce emissions two-fold. These results prove that the industrial sector, as an economic driver, has a role in reducing emissions through energy efficiency.

Energy efficiency can also be achieved through digital technology, as shown by a study conducted by Wu et al. (2023) in China. Their research results show that digital technology represented by industrial robots can increase energy efficiency in the industrial sector in China. A relatively similar study was conducted by Liu et al. (2022) using artificial intelligence and found that AI can increase energy efficiency in the manufacturing industry in China. This study's results confirm the role of digital technology in achieving energy efficiency in the manufacturing sector.

Previous studies have shown how energy efficiency is measured and the influence of fiscal and monetary policies on energy efficiency. The analysis is still an economic sector that does not cover overall energy use. The efficiency measures also differ from one study to another. Aggregate efficiency has been carried out by Bai et al. (2024) but on the efficiency of resource use. Energy is part of the resource, so this energy efficiency measure can be used by making special modifications for energy only. The results of this study prove that fiscal and monetary policies significantly influence emission reduction and resource efficiency.

3. RESEARCH METHOD

The data used in this study are secondary data from various official publications with a sample size of 96 quarters from the first quarter of 2000 to the fourth quarter of 2023. The variables used are energy efficiency, which is the contribution of the energy sector to Gross Domestic Product (GDP); the economy, which is measured by the Industrial Production Index (IPI); fiscal policy, which is the contribution of government spending to GDP; and finally, monetary policy is represented by the 3-month loan interest rate. Only IPI is transformed into natural logarithm form because other variables are already in percentage.

The model used in this study is based on the results of the stationarity test of the data used. If the variables used in this study have different levels of stationarity, then the most appropriate model used is Autoregressive Distributed Lag (ARDL). The ARDL model can be expressed in the form:

$$\Delta EE_t = \beta_1 + \sum_{i=1}^{j2} \beta_2 EE_{t-i} + \sum_{i=0}^{j3} \beta_3 ln\Delta IPI_{t-i} + \sum_{i=0}^{j4} \beta_4 \Delta G_{t-i}$$

$$+\sum_{i=0}^{j5} \beta_5 \Delta R_{t-i} + \theta_1 EE_{t-1} + \theta_2 lnIPI_{t-1} + \theta_3 G_{t-1} + \theta_4 R_{t-1} + \varepsilon_t \quad (1)$$

The *EE* is energy efficiency, *IPI* is industrial production index as a proxy of economy, *G* is fiscal policy, *R* is monetary policy, and ϵ is residuals and assumed to be white noise. The coefficient of β_1 is a constant term, $\beta_2 .... \beta_4$ are short-run coefficients and θ_k are long-run coefficients for *k* from 1 to 4.

3.1. Testing for Short–Run Dynamic Model

The dynamic short-term impact test of fiscal and monetary policies was conducted using the Wald test (Table 1). Furthermore, a test was also conducted to see whether fiscal and monetary policies were the same for energy efficiency. This hypothesis test is stated as follows:

4. FINDINGS AND DISCUSSION

4.1. Findings

The first stage before estimating the appropriate model is to determine the stationarity of the variables used in this study using the Augmented Dickey-Fuller (ADF) approach. The results of the stationarity test are in Table 2, where one variable is stationary at the level, and three other variables are stationary after the first difference. Based on the results of this stationarity test, the appropriate model used in this study is ARDL.

After determining the appropriate model, the next step is determining the optimal lag used for ARDL model estimation. The optimal lag is determined using the Akaike Information Criteria (AIC), and it is obtained at 1, 2, 3, 5, as in Figure 2.

The model stability test is one way to determine whether the model used meets the requirements in this analysis. The test uses the CUSUM and CUSUM Square approaches, as shown in Figure 3, panels (a) and (b). Figure 3 shows that the model used is stable, so it can be used as an analysis tool in this study.

Tests on several selected classical linear regression assumptions were conducted to determine whether there were any serious violations. The test was a serial correlation test with the LM test, and the results in Table 3 show no serial correlation in the estimation results. Furthermore, the heteroscedasticity test was conducted using the ARCH test approach, proving there was no heteroscedasticity. However, the normality test with Jarque–Berra (JB) showed that the residuals were not normally distributed. Violation of the normality assumption results in inefficient estimation, but the results are not biased. With these considerations, this model can still be used for analysis in this study.

Table 1: Testing for short–run dynamic role of fiscal and monetary policies

Policy testing	Null Hypothesis	Alternative Hypothesis
Economy	$\sum_{i=0}^{j3}\beta_3 = 0$	$\sum_{i=0}^{j3}\beta_3 \neq 0$
Fiscal Policy	$\sum_{i=0}^{j4}\beta_4 = 0$	$\sum_{i=0}^{j4}\beta_4 \neq 0$
Monetary Policy	$\sum_{i=0}^{j5}\beta_5 = 0$	$\sum_{i=0}^{j5}\beta_5 \neq 0$
Fiscal Policy=Monetary Policy	$\sum_{i=0}^{j4}\beta_4 = \sum_{i=0}^{j5}\beta_5$	$\sum_{i=0}^{j4}\beta_4 \neq \sum_{i=0}^{j5}\beta_5$

4.2. Discussion

After the ARDL model requirement test results are carried out, this stage discusses the estimation results. Bound Testing shows a short-term equilibrium towards the long term, as shown in the results in Table 4. According to Pesaran (2001), the decision to reject the null hypothesis (no cointegration) is if the F-statistic value is greater than the lower and upper bands. If the F-stat is between the two bands or smaller than the band then the conclusion is that we accept the null hypothesis. Our findings found the f-stat numbers to be greater than both bands at the 10% level. These results indicate a short-term equilibrium towards the long-term at I(0). This condition illustrates that in the long term, the development of the Indonesian economy, which is getting bigger, will be able to create an economy of scale, and this condition will achieve energy efficiency in Indonesia, especially with the support of fiscal and monetary policies to encourage economic actors to strive to achieve energy efficiency. Energy efficiency in the long term is very important to ensure the sustainability of resource use in the long term.

The short-term estimation results in Table 5 show that the error correction term coefficient meets the requirements in the ARDL model because it is negative and significant. The error correction term coefficient value of -0.2630 means that if there is a shock to energy efficiency, it will take 23 days to return to equilibrium before the shock. This condition is rational because most of the production cost structure is energy, so even the smallest shock will be anticipated by any economic sector to achieve energy efficiency.

Economic development, represented by the Industrial Production Index, has a positive and significant effect on the first lag. This

Figure 2: Optimal lag selection

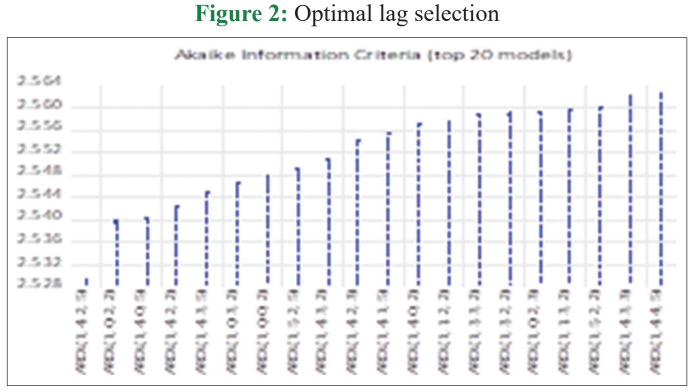


Table 2: ADF stationary test of the variables

Variable	Statistics				Conclusion
	At level	P-value	First difference	P-value	
Energy	−2.42215	0.3660	−9.02563	0.0000	I (1)
Fiscal Policy	−1.86002	0.6669	−5.70486	0.000	I (1)
IPI	−2.61045	0.2769	−11.4846	0.000	I (1)
Monetary Policy	−3.7593	0.0232	−5.3968	0.000	I (0)

Source: Estimated results, 2024

Figure 3: (a and b) CUSUM and CUSUM squares model stability tests

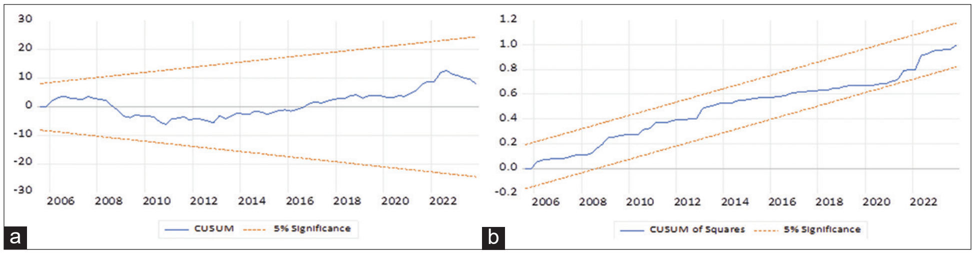


Table 3: Testing for Selected Assumptions of Classical Linear Regression Model

Diagnostics tests	Statistics	p-value	Null Hypothesis	Conclusion
LM Test	0.1736	0.8410	No serial correlation exists	Accept Ho
ARCH	0.0804	0.7775	No heteroscedasticity exists	Accept Ho
Jarque–Berra	9.5625	0.0084	Normally distributed	Reject Ho

Source: Estimated Results, 2024.

Table 4: Bound test of long–run relationship

Actual sample size	Statistics	Significant (%)	I (0)	I (1)
80	4.47*	10	3.588	4.605
		5	4.203	5.32
		1	5.62	6.908

Source: Estimated Results, 2024. * mean level of significance at 10%

Table 5: Estimated results of short–run ARDL model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	30.6469***	7.1465	4.2884	0.0001
@TREND	−0.0333***	0.0085	−3.9131	0.0002
D(G)	−0.3217**	0.1224	−2.6292	0.0104
D(G(−1))	−0.1203	0.1176	−1.0233	0.3095
D(G(−2))	−0.1520	0.1188	−1.2793	0.2048
D(G(−3))	−0.2903**	0.1206	−2.4079	0.0185
D(LIPI)	−1.1137	4.4213	−0.2519	0.8018
D(LIPI(−1))	9.3945**	4.3427	2.1633	0.0337
D(R)	0.5931**	0.2522	2.3516	0.0214
D(R(−1))	−0.5982*	0.3090	−1.9359	0.0567
D(R(−2))	0.3396	0.2909	1.1676	0.2467
D(R(−3))	−0.0871	0.2795	−0.3116	0.7562
D(R(−4))	0.6272**	0.2670	2.3488	0.0215
CointEq(−1)*	−0.2630***	0.0610	−4.3134	0.0000

Source: Estimated Results, 2024. *, ** and *** represent level of significance 10%, 5%, and 1%

indicates that economic progress will affect the increase in economic scale while achieving energy efficiency.

Meanwhile, the short-term influence of fiscal policy variables has a significant negative effect on the first and third lags. This indicates that fiscal policy can reduce energy efficiency, especially when government budget allocations cannot encourage economic actors to increase energy efficiency. It is necessary to allocate the right budget and encourage all parties to achieve energy efficiency in production. Furthermore, monetary policy positively and significantly affects energy efficiency in the first lag. However, the next lag has a negative effect on energy efficiency. This condition is an indication that handling monetary policy must be able to encourage energy efficiency.

Only monetary policy has an impact on long-term energy efficiency. However, the negative impact of monetary policy illustrates that monetary policy can reduce energy efficiency. Monetary policy must be improved to encourage business actors to achieve energy efficiency. Incentives for economic actors in the form of lower interest rates must be increased so that energy usage costs are cheaper and energy efficiency can be achieved. The results of this long-term estimate can be seen in Table 6.

This study's results differ from those of Sineviciene et al. (2017), who used the stochastic frontier approach and found that the economy is an important determining variable for energy efficiency in 11 Eastern European countries. This could be different because the approach in their study is energy efficiency, which is measured by GDP per 1 kg of oil. Furthermore, the study conducted by Syaifudin et al. (2015) is also different because their study uses the CGE approach. The results of other partial studies are also different, such as the study conducted by Irsyad and Nepal (2016) on energy efficiency specifically for street lighting, Rahardjo et al. (2021) researching the efficiency of government-owned warehouses, and Nugroho and Syaifudin (2018) who researched the effect of renewable energy on energy efficiency.

Meanwhile, short-term policy testing is done dynamically using the Wald test, and the test results are presented in Table 7. First, fiscal policy shows that it significantly affects energy efficiency in the short term dynamically. This is evidence that, cumulatively, fiscal policy significantly affects energy efficiency. This is different from each lag, which has a negative effect on energy efficiency. Furthermore, dynamic monetary policy also significantly affects energy efficiency in the short term. This result motivates policymakers to work together to encourage energy efficiency. Only the economy does not have a dynamic effect in the short term.

The results of this study confirm the research conducted by Syaifudin et al. (2015), who found that fiscal incentives to regions significantly impact energy efficiency. The same results were found in the research conducted by Nurcahyanto et al. (2020), who found that combining policies is a very important factor in achieving energy efficiency in Indonesia.

Table 6: Long–run estimated ARLD model

Variable	Coefficient	Standard Error	t-Statistics	Probability
EE(−1)*	−0.2630	0.0685	−3.8372	0.0003
G(−1)	−0.2706	0.1689	−1.6022	0.1134
LIPI(−1)	−8.9741	5.7142	−1.5705	0.1206
R(−1)	−0.4714	0.1519	−3.1037	0.0027

Source: Estimated results, 2024

Table 7: Testing for monetary, fiscal policies, economic growth, and symmetric policies

Policy testing	Wald Statistics	Probability	Conclusion
Fiscal policy	2.4444**	0.0417	Reject Ho
Monetary policy	4.4859***	0.0000	Reject Ho
Economy	1.4894	0.2244	Accept Ho
Fiscal Policy=Monetary Policy	1.1538	0.2521	Accept Ho

Source: Estimated Results, 2024. ** and *** represent level of significance 5%, and 1%

5. CONCLUSION

There are several conclusions from the results of this study. First, dynamic fiscal policy in the short term affects energy efficiency in Indonesia. Second, dynamic monetary policy in the long term affects energy efficiency in Indonesia. Third, fiscal and monetary policies have the same effect on energy efficiency in Indonesia. Based on the results of this study, policymakers are encouraging energy efficiency in Indonesia. The government must increase budget allocations to encourage economic actors to accept energy efficiency efforts in production. Furthermore, Bank Indonesia, as the central bank, has a role in encouraging energy efficiency in Indonesia by providing incentives to reduce interest rates for economic actors who use energy-saving technology.

6. ACKNOWLEDGMENTS

Thank you to LPPM Universitas Syiah Kuala for funding this research by contract number 252/UN11.2.1/PG.01.03/SPK/PTNBH/2024, dated May 3, 2024. We would also like to thank the Faculty of Economics and Business, Syiah Kuala University, and the Faculty of Business, Economics, and Social Development, Universiti Malaysia Terengganu, Malaysia, for participating in this research.

REFERENCES

Adha, R., Hong, C.Y., Firmansyah, M., Paranata, A. (2021), Rebound effect with energy efficiency determinants: A two-stage analysis of residential electricity consumption in Indonesia. Sustainable Production and Consumption, 28, 556-565.

Bai, X., Zhong, J., Huang, D. (2024), Economic instruments for natural resource efficiency: The role of carbon taxation and fiscal policy. Resources Policy, 89, 104614.

Erahman, Q.F., Purwanto, W.W., Sudibandriyo, M., Hidayatno, A. (2016), An assessment of Indonesia's energy security index and comparison with seventy countries. Energy, 211, 364-376.

Hasan, M., Mahlia, T., Nur, H. (2012), A review on energy scenario and sustainable energy in Indonesia. Renewable and Sustainable Energy Reviews, 16(4), 2316-2328.

IESR. (2023), Indonesia Energy Transition Outlook 2024: Peaking Indonesia's Energy Sector Emission by 2030: The Beginning or The End of Energy Transition Promise. Jakarta: Institute for Essential Services Reform (IESR). Available from: https://iesr.or.id/wp-content/uploads/2023/12/indonesia-energy-transition-outlook-ieto-2024.pdf [Last accessed on 2024 Aug 14].

Irsyad, M.I., Nepal, R. (2016), A survey based approach to estimating the benefits of energy efficiency improvements in street lighting systems in Indonesia. Renewable and Sustainable Energy Reviews, 58, 1569-1577.

Kusumadewi, T.V., Limmeechokchai, B. (2015), Energy efficiency improvement and CO_2 mitigation in residential sector: Comparison between Indonesia and Thailand. Energy Procedia, 79, 994-1000.

Liu, J., Qian, Y., Yang, Y., Yang, Z. (2022), Can artificial intelligence improve the energy efficiency of manufacturing companies? Evidence from China. International Journal of Environmental Research and Public Health, 19, 2091.

Nugroho, F., Syaifudin, N. (2018), Partial-factor Energy Efficiency Model of Indonesia. In: The 3rd International Conference on Electrical Systems, Technology and Information (ICESTI 2017). Vol. 164. Les Ulis Cedex A, France: EDP Sciences-Web of Conferences. p01009.

Nurcahyanto, Simsek, Y., Urmee, T. (2020), Opportunities and challenges of energy service companies to promote energy efficiency programs in Indonesia. Energy, 205, 117603.

Pesaran, M.H., Shin, Y., Smith, R.J. (2001), Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics, 16(3), 289-326.

Rahardjo, I.A., Djaohar, M., Subekti, M., Parjiman, Zakir, I., Mahir, I., Lubis, A. (2021), Analysis of energy consumption and energy efficiency in government office buildings of Bengkulu, Indonesia. Journal of Physics: Conference Series, 2111, 012052.

Rosita, T., Zaekhan, Estuningsih, R.D., Widharosa, N. (2020), Does energy efficiency development in manufacturing industry decouple industrial growth from CO_2 emissions in Indonesia? International Journal of Environmental Studies, 78(4), 573-587.

Sineviciene, L., Sotnyk, I., Kubatko, O. (2017), Determinants of energy efficiency and energy consumption of Eastern Europe post-communist economies. Energy and Environment, 28(8), 870-884.

Syaifudin, N., Sutrisno, A., Setiawan, A.D. (2015), The impact of fiscal transfer on energy efficiency in Indonesia. Energy Procedia, 65, 239-247.

Wu, H., Han, M., Shen, Y. (2023), Technology-driven energy revolution: The impact of digital technology on energy efficiency and its mechanism. Frontiers in Energy Research, 11, 1242580.